



## Buildings in the 21st Century: Ultra-Efficient and Business-Smart Strategies for Transforming the Nation's Buildings

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## **KEYNOTE ADDRESS**

### **BUILDING THE 21ST CENTURY: ULTRA-EFFICIENT AND BUSINESS-SMART STRATEGIES FOR TRANSFORMING THE NATION'S BUILDINGS**

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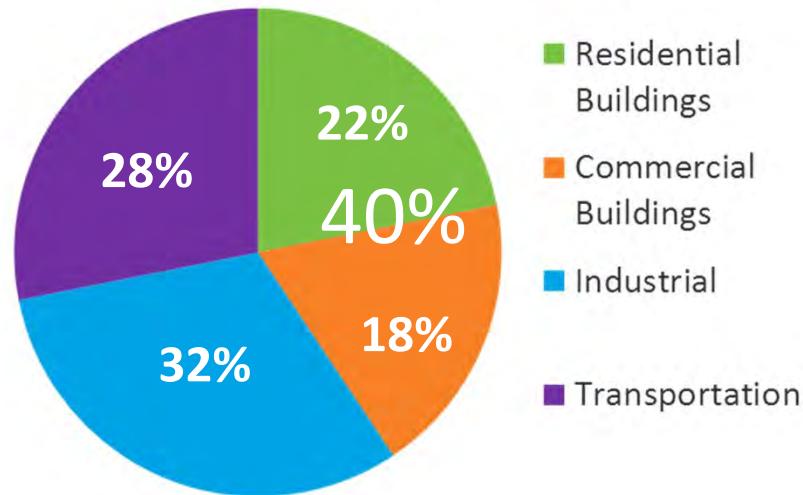
**T**he presentation will provide an overview of the cutting-edge efficiency strategies and technologies being employed to design new and renovate existing buildings – and show how federally sponsored research and development supports this progress.

# The U.S. Energy Big Picture...

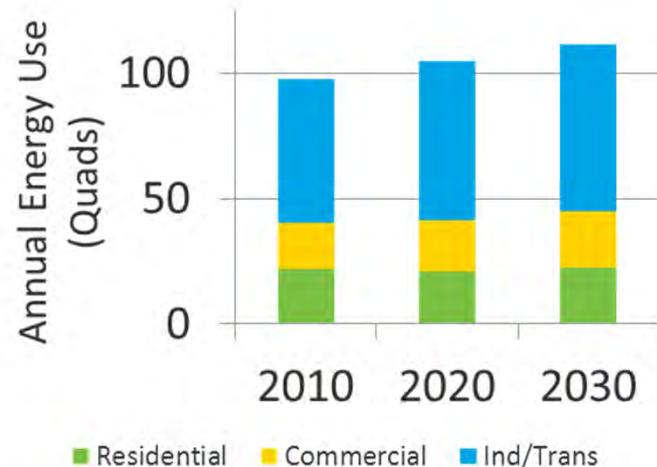
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## U.S. Primary Energy Consumption



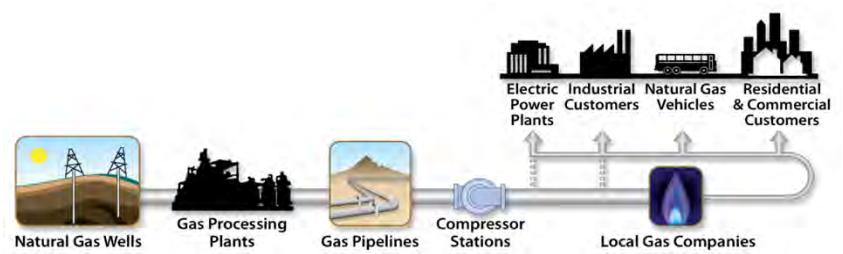
## Total U.S. Energy Consumption



## 73% of U.S. Electricity Consumption



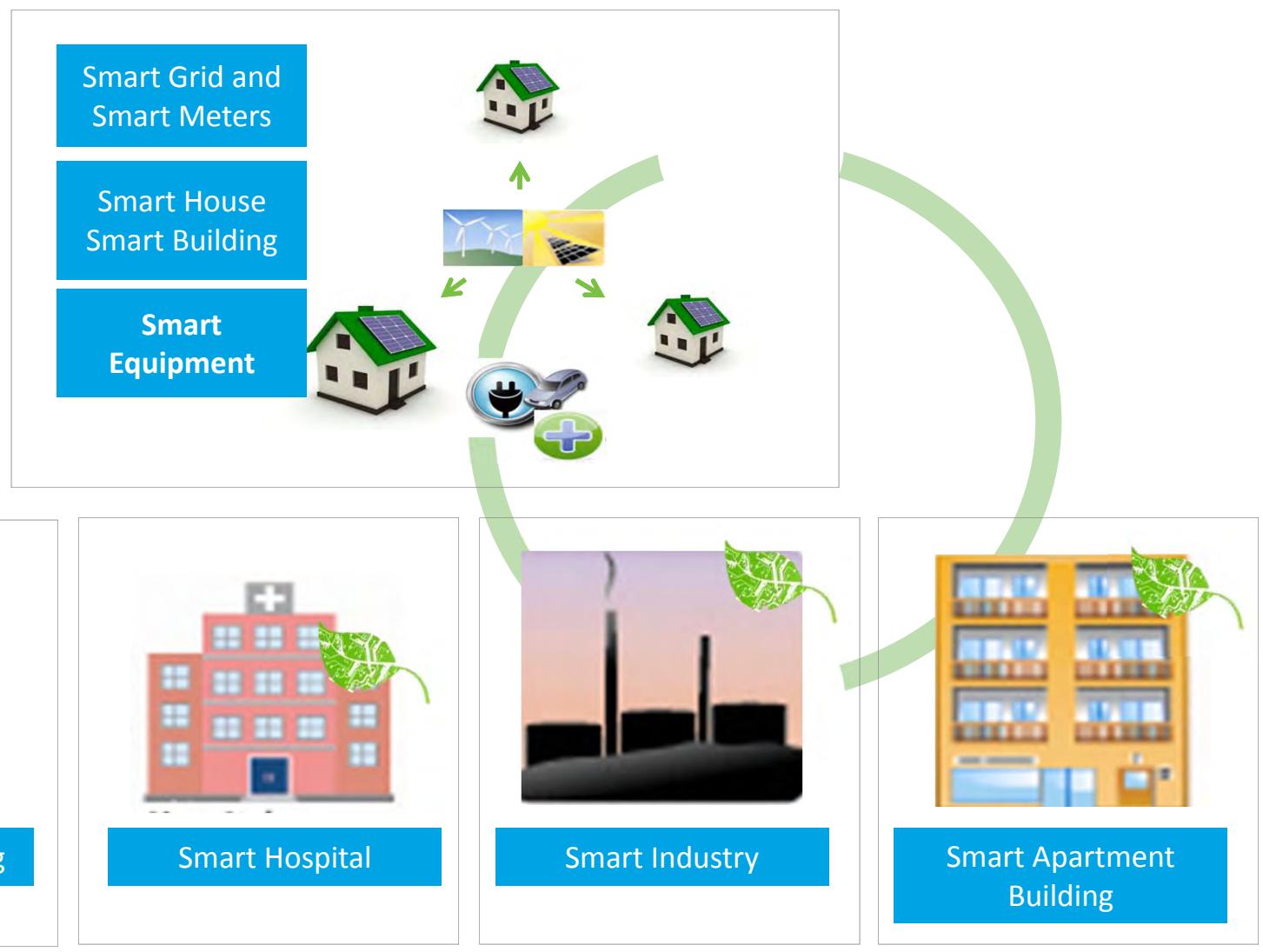
## 55% of U.S. Natural Gas Consumption



# Future Opportunities for an Energy Efficient Nation

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# The Building Technologies Program (BTP) uses an Integrated Approach to Deliver Savings

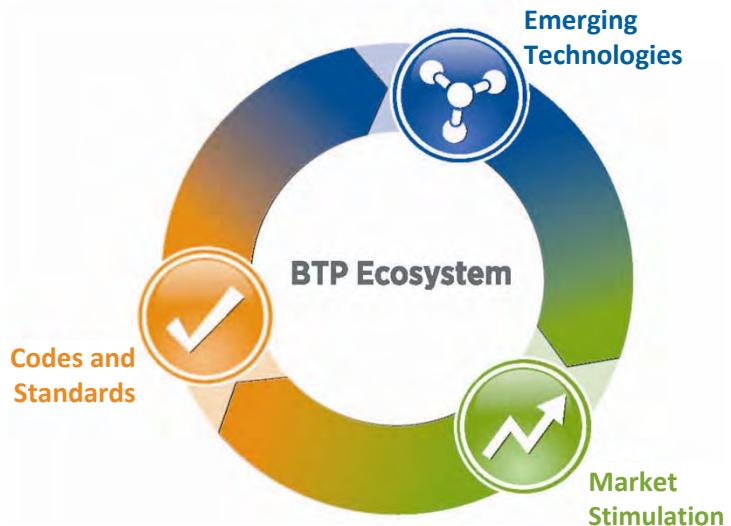
## Research & Development

- Develop technology roadmaps
- Prioritize opportunities for DOE
- Solicit and select innovative technology solutions
- Collaborate with researchers and market performers
- Solve technical barriers and test innovations to prove effectiveness
- Measure and validate energy savings



## Market Stimulation

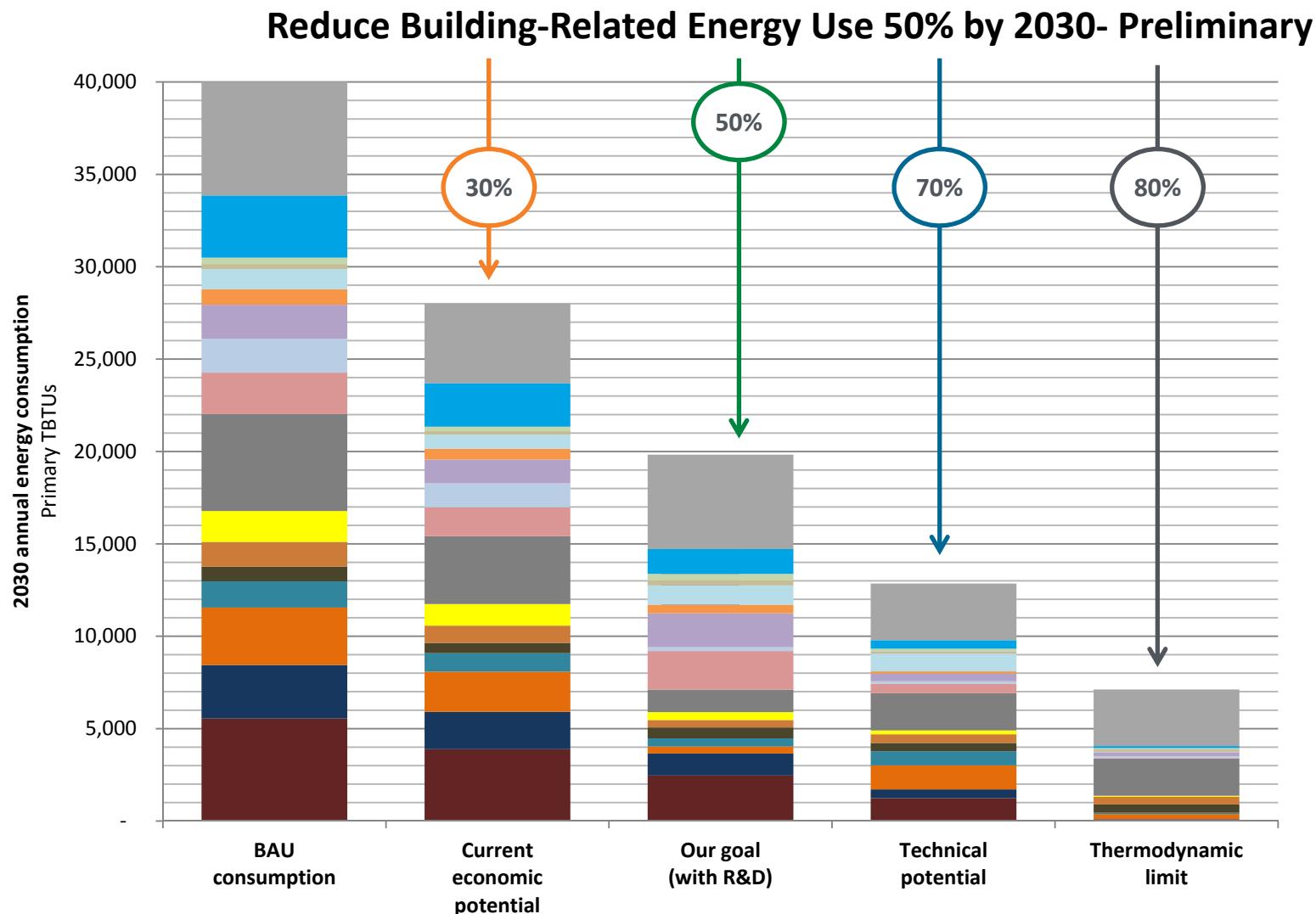
- Identify barriers to “speed and scale” adoption
- Develops solutions to policy, adoption, and financial barriers
  - Collaborate with industry partners to improve market adoption
  - Increase usage of products and services
  - Communicate the importance and value of energy efficiency
  - Provide technical assistance
  - Support development of workforce training and certification



## Codes and Standards

- Establish minimum energy use in a transparent public process- raise the efficiency bar
- Protect consumer interests
- Reduce market confusion
- Enhance industry competitiveness and profitability
- Expand portfolio of energy efficient appliances and equipment

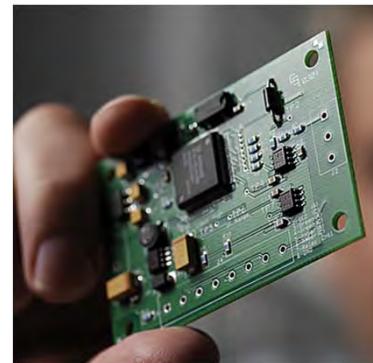




Source: BTP Prioritization tool, NAS, McKinsey.

# What might the Market look like 5 years from Now?

- **Cooler:** Significant advancements in cooling and refrigeration technology enable the market to choose from a larger variety of energy-efficient products at competitive prices
- **Brighter:** DOE recognizes that solid-state lighting has the potential to save significant energy
- **Smarter:** Advances in sensor & control technology are improving our ability to detect faults, diagnose problems, and facilitate repairs before costly failures occur; products are getting 'smarter' AND more efficient

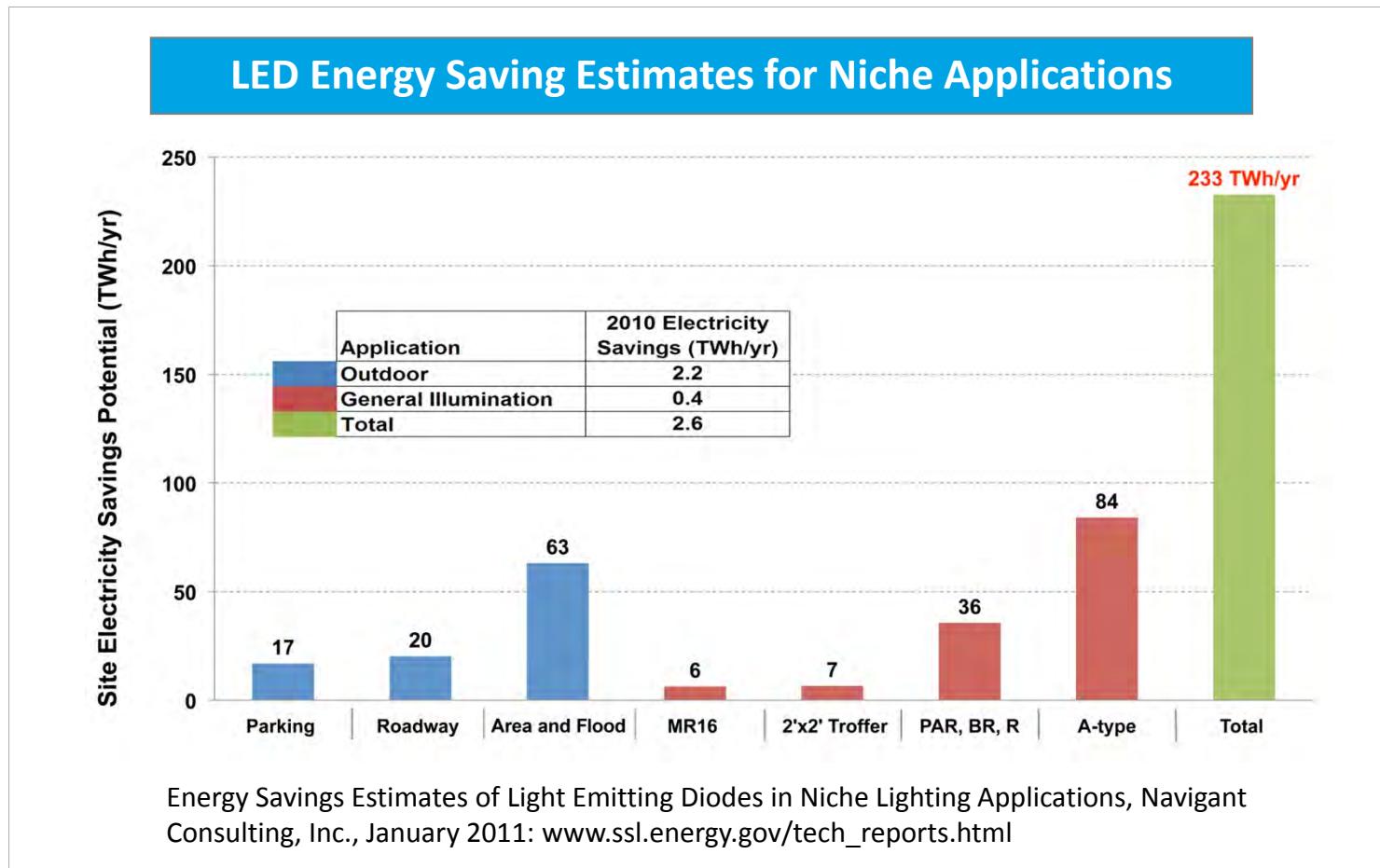


# Emerging Technologies: LED Savings Potential is Significant



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- Electricity savings potential of niche LED-based lighting = **233 TWh/yr**
- Equivalent to the electricity needed to power **19 million households**



# Emerging Technologies: LED Applications Will Be Game Changers



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- **Solid-state lighting (SSL) technology has the potential to cut U.S. lighting energy use by ¼ and contribute to U.S. climate change solutions**
- DOE, its national laboratories, and Commercial Building Energy Alliance (CBEA) members are working to support the market deployment of LED parking lot lighting



- A Walmart in Leavenworth, Kansas, has the first retail parking lot to meet the CBEA LED parking lot site specification
- Walmart expects LEDs to reduce energy needs in its parking lots by more than 50%, delivering average energy savings of <125,000 kWh/year per site
- Walmart has planned for over 225 new sites that will include this LED parking lot lighting specification

# Emerging Technologies: Building Envelope has an Expansive Portfolio



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- Roofs:
  - Increase aged performance of roof coatings by 25%
  - Develop cost effective “cool-colored” asphalt shingles with no increase in 20 year life cycle cost by 2015
  - Next gen attic systems with 50% savings
- Windows:
  - Develop a cost-effective R-10 window
  - 0.1 U-Value windows at \$3/sq ft price premium by 2020
- Insulation:
  - Dynamic insulation with over 20% peak load reduction
  - Dynamic annual performance of attics and walls with no increase in life cycle cost by 2015
- Building Integrated PV with higher PV output and min. 25% thermal load reduction

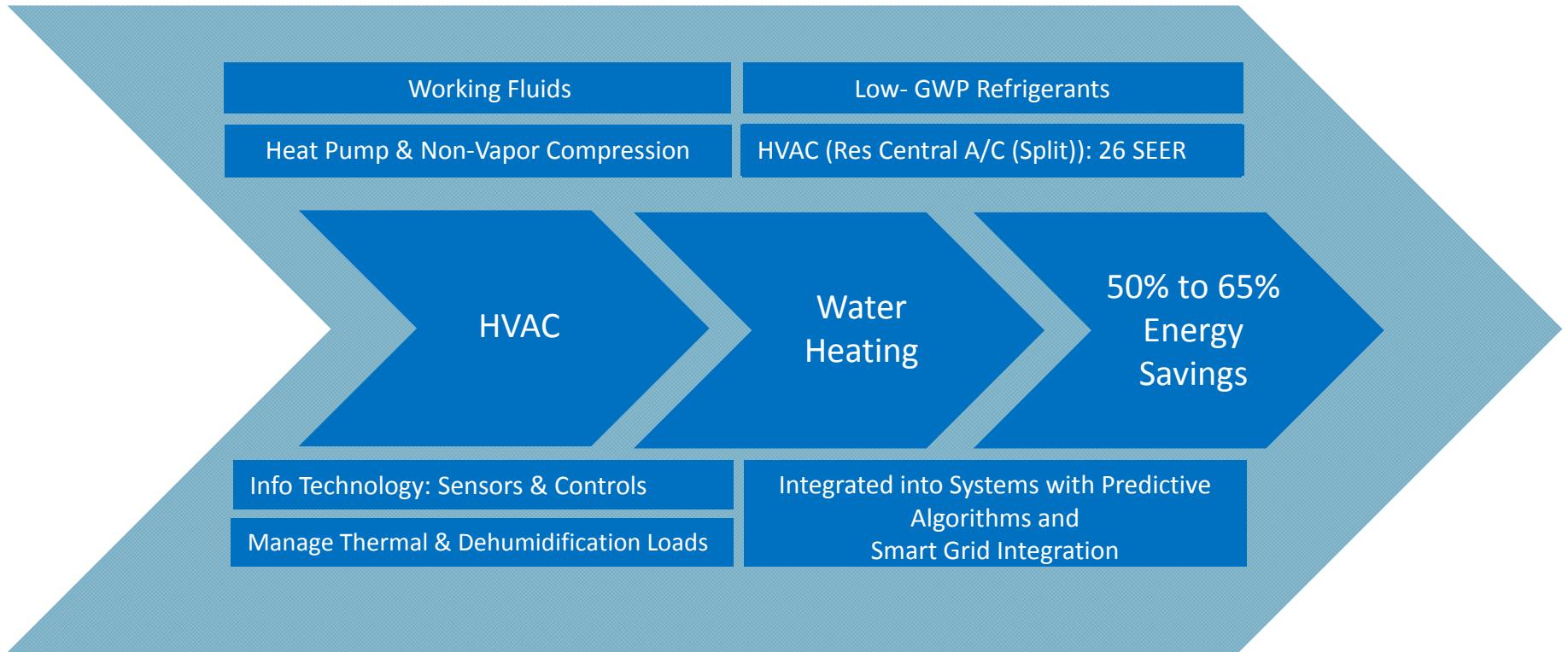


Sample advanced roof design applied to BIPV to be evaluated (50% reduction of roof thermal load)

# Emerging Technologies: HVAC, Water Heating, and Working Fluids Make the Push for Big Energy Savings



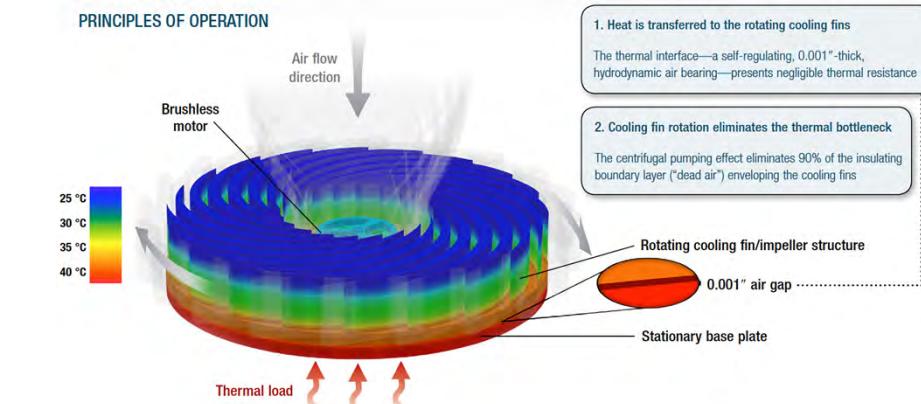
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# Emerging Technologies: Heat Exchangers will Significantly Impact many End Uses

- Crosscutting technology: Heat exchangers are used not only in refrigeration, heating, and air conditioning but also nearly every application that generates waste heat
- Potentially impacting 21 quadrillion BTUs (53%) of building energy consumption
- First application - Data Center cooling loads (chip cooling)

New heat exchange technology has a 30x improvement versus current technologies



Technical white paper: <http://prod.sandia.gov/techlib/access-control.cgi/2010/100258.pdf>

- **Improved Air-Source Heat Pumps (ASHP) for Cold Climates**
  - Potential 50% – 70% savings at low ambient temps vs. current min efficiency ASHP
- **Multifunction Electric Heat Pumps** (Space conditioning, water heating, dehumidification, and ventilation)
  - Potential 40% – 65% energy savings for HVAC/WH vs. suite of individual systems
    - 13 SEER ASHP, 0.9 Energy Factor (EF) Water Heater, 1.4 EF stand alone dehumidifier, whole house ventilation per ASHRAE 62.2
    - Two-speed and variable speed compressor versions;
    - Variable speed fans and pumps
- **Residential Multi-Function Fuel-Fired Heat Pump**
  - Potential 70% peak demand savings; 40% source energy savings vs. min efficiency electric heat pump
  - Space conditioning, dehumidification, water heating, up to 3 kW of electrical energy

Example Application: Heat Pump Coupled Washer/Dryer - heat pump cycle to facilitate intracycle heat recovery and minimize energy use- 2011-2013 project time frame

# Emerging Technologies: A Next Generation Window Air-Conditioner (WAC) can Deliver 30% Energy Savings



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- **Aim: WAC unit in 1.5 – 3.5 kW cooling capacity range with a energy efficiency ratio (EER) of 13**
- 30% energy savings vs. current minimum efficiency standard
- Market & Energy Saving Potential
  - US has ~57 million units in use
  - Current DOE minimum EER is 9.8
  - Replacement of existing units with advanced WACs could save ~2.5 quads of energy over next 20 years
  - Future Cooperative Research and Development Agreement (CRADA) project



- Technology Specifications – Market Driven
- Minimum Performance Standards
- Training and Certification Programs
- Technology Identification and Screening
- Successful Retrofit Business Models – Better Buildings
- Building Performance Database – Standardized Data Taxonomy
- Advanced Retrofit Guides
- Advanced Design Guides
- Modeling and Tools
- Superior Energy Performance

## Working with Industry to Drive Innovation: The RTU Challenge

- Package units such as RTUs use ~ 50% of the cooling energy in commercial buildings
- ~40,000 ten ton RTUs sold/year
- Challenge U.S. manufacturers to build and deliver innovative, competitively priced, energy-saving rooftop HVAC units (RTUs) that meet CBEA high-performance specification requirements such as
  - ARI rated efficiency from baseline 11.0 EER/11.2 IEER to 18 IEER
  - Decrease air flow by specifying variable over constant air volume
  - Increase fan efficiency from 45% to min. 60% with variable volume or multi-stage operation capability

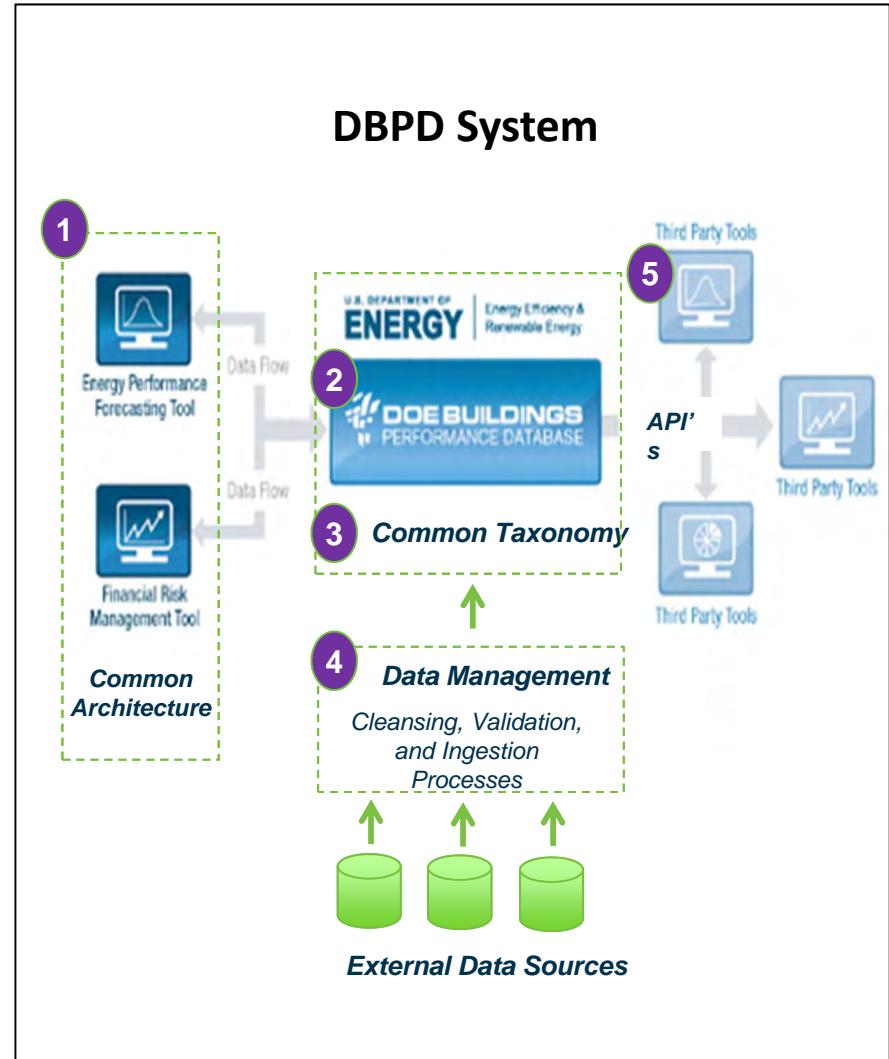


# Deployment: The DOE Building Performance Database (DBPD)



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- 1 **Applications:** Web-enabled tools that leverage data to forecast energy savings and related cash flows.
  - As more use-cases are identified, additional tools will be created and released to the market
- 2 **Data Warehouse:** platform to house Energy data within standard taxonomy
- 3 **Common Taxonomy:** a standardized “data model” to organize energy use and building characteristic data
- 4 **Data Management:** processes and tools to support the on-boarding and validation of data from multiple sources
- 5 **3<sup>rd</sup> Party Tool Support:** API’s that allow 3<sup>rd</sup> Party developers to create applications that use DBPD data



# RSF Design/Build Process Drives Efficiency through Integrated Approach



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- **Performance based**, not solution/prescriptive Request for Proposal (RFP)
- No drawings/plans in the RFP
- Short list of qualified Design-Build Teams complete with RFP
- Design decisions from energy modeling
- Optimal use of “free” energy sources
- **Select best value for a fixed price**
  - Data center waste heat recovery
  - Evaporative cooling in dry climate
  - Day lighting
- Single contract to Design-Build firm
- Financial incentive for superior performance
- Substantiate design and construction elements to validate performance



Cutting energy consumption in half at zero added cost is possible.

# Greater Philadelphia Innovation Cluster for Energy Efficient Buildings Integrates Systems

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- **House and Foster Collaboration** between research, training, and commercialization activities focused on clean and energy efficient processes, policies, and technologies
- **Function as a Living Laboratory** to research and demonstrate processes and products identified and/or developed by the HUB as scalable, near market-ready retrofit approaches
- **Serve as a regional resource** that makes energy efficiency attractive to building owners, researchers, and policy-makers
- **Demonstrate intersection of energy efficiency and energy effectiveness** (efficient spaces that are comfortable, healthy, functional, and appealing)



# Facility Energy Decision System (FEDS) brings Big Value to Energy Industry



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- FEDS estimates energy consumption for all energy systems & fuels types
- FEDS determines the minimum life-cycle-cost of retrofits to systems within a single facility and for an entire installation or campus, considering interactive effects
- FEDS can be used by government or private sector for single or multi-building campuses to quickly and easily assess:
  - Energy efficiency opportunities
  - Energy/\$ savings
  - Emission reductions



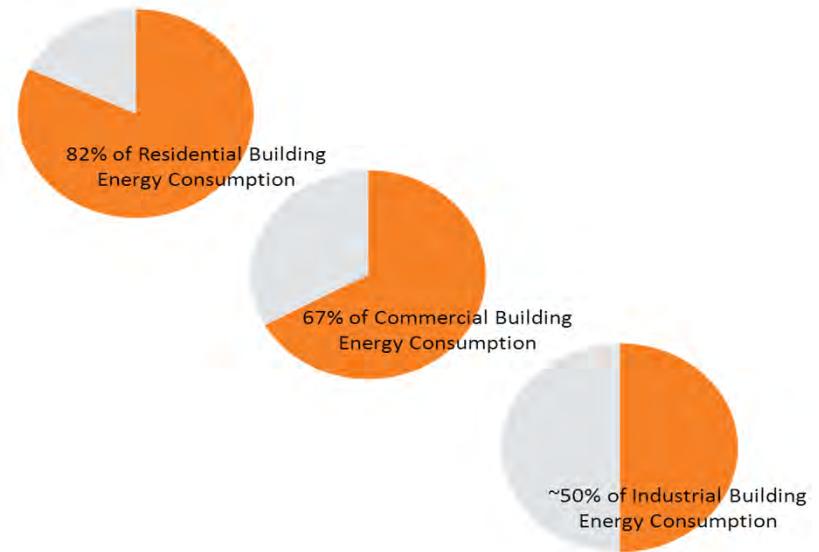
# Appliance Standards and Test Procedures is DOE's Most Effective Energy Saving Program



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- Energy saved since first 1987 standards = construction of ~31 power plants avoided or the amount of electricity consumed annually by Spain
- 1988 – 2006 standards est. cumulative energy savings = 39 quads by 2020 and 63 quads by 2030
- Cumulative consumer benefit\*:
  - \$64 billion at the end of 2005
  - \$150 billion as of 2010
  - \$241 billion by 2030
  - \$269 billion by 2045
- Annual carbon savings will reach 38 million tons by 2020
- Cumulative carbon savings by 2045 is estimated at 1,200 million tons

- <\$650 in net savings for every federal dollar spent
  - Consumers and businesses are saving \$15 billion a year as of 2010 and this is expected to nearly double by 2025
- Over 50 products covered:



\*Net present value

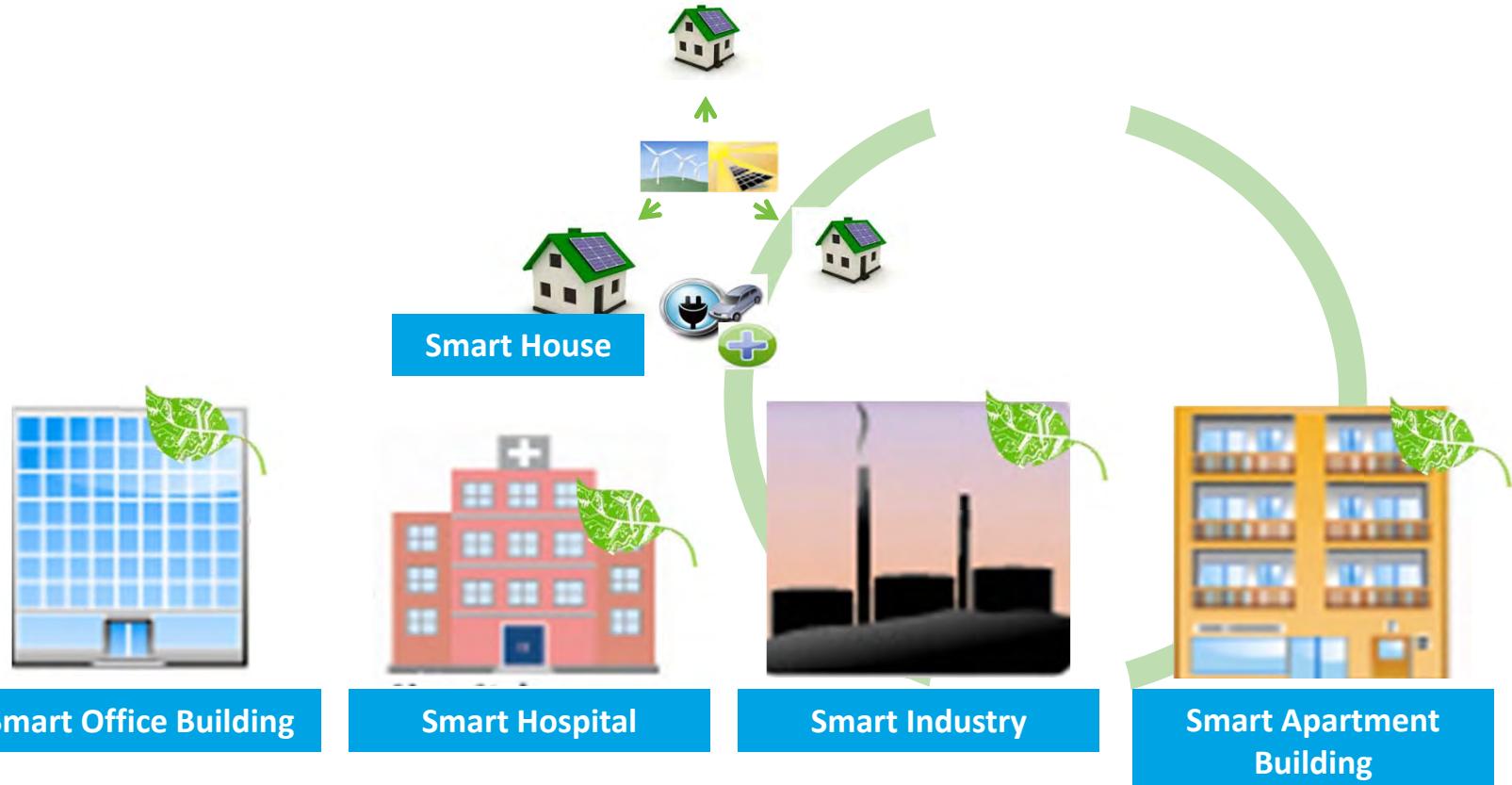
## And From There? Future Opportunities...

## Distributed Generation Systems: Dynamic Control

## Smart equipment: Auto demand response, self-correcting

## Energy storage with local generation: PV, wind, batteries, thermal storage

## DC vs. AC: Minimize transformer losses



- DOE is actively working to balance...
  - US investments in high potential advanced technologies, integrating the recyclability of the components in the initial design
  - Developing tools and strategies to drive market adoption of energy efficient approaches and innovations
  - Removing excessively inefficient technologies and practices from the market through cost effective codes and equipment standards

....While focusing on accelerating a future where energy is easily, transparently, and cost effectively managed without negatively impacting our quality of life

# Thank You